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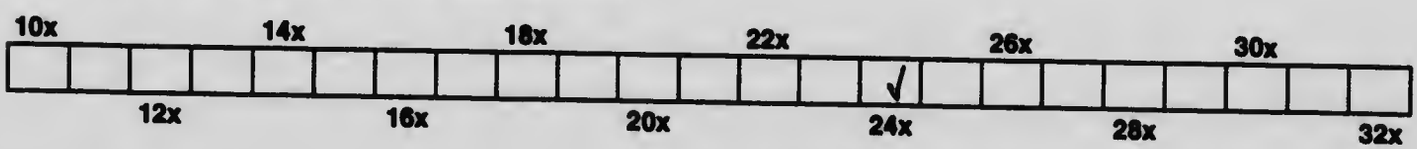

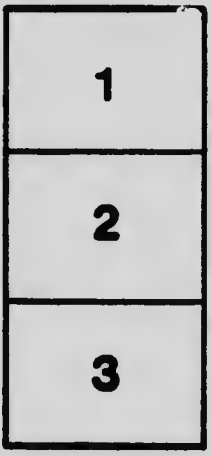

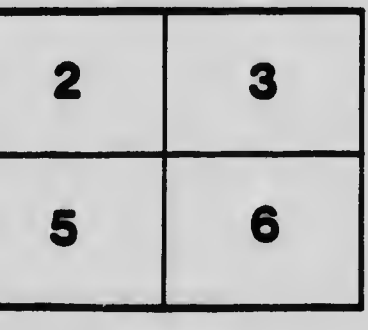

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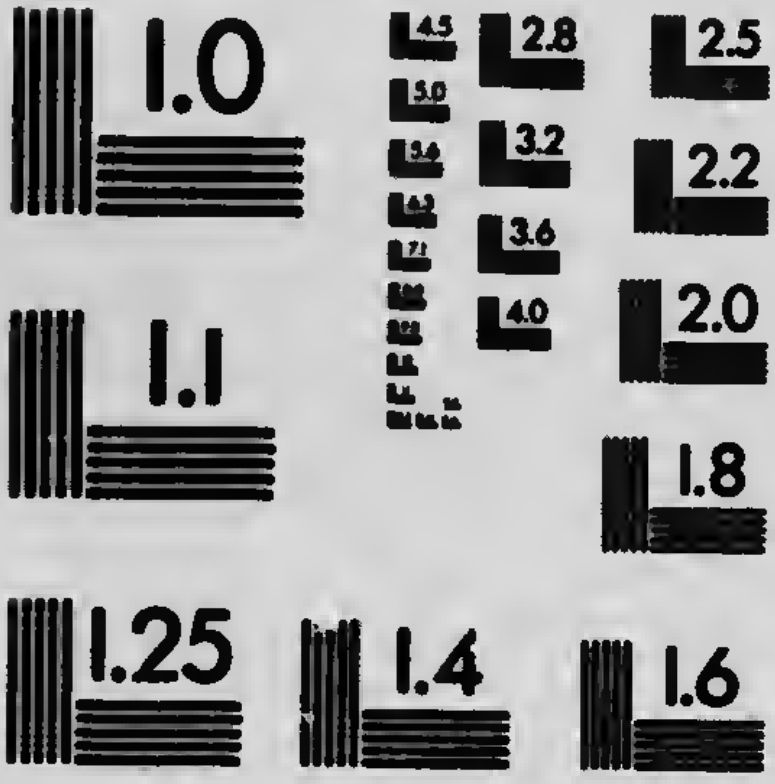

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CANADIAN FISHERIES EXPEDITION, 1914-1915

BIOLOGY OF ATLANTIC WATERS OF CANADA

GROWTH OF THE YOUNG HERRING (SO-CALLED SARDINES) OF THE BAY OF FUNDY

A PRELIMINARY REPORT

BY

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In the spring of 1915 Dr. Hjort proposed in connection with the extended investigations in 1914-15 that I study the young of the herring (*Clupea harengus*) or "sardines" of the Bay of Fundy to determine if possible how large they were during the first winter, and the amount of growth during the year. The numerous Canadian weirs that are fished throughout the greater part of the year to supply the sardine factories chiefly in Maine were practically certain to furnish an abundance of material.

Owing to the work that was being prosecuted in the gulf of St. Lawrence it was not possible for me to examine the material in the fresh state except at the beginning and end of the season. It was necessary to rely upon salted material.

The material has been collected in large part by the engineer of the Biological Station at St. Andrews, Mr. A. E. Calder. When circumstances permitted, he collected samples weekly. The material has proved to be far from complete enough to settle the points in question. This is particularly the case with regard to the smaller fish, popularly known as "brit," which are for the most part too small to be satisfactorily taken by the nets used in seining the weirs. Not only will they pass through the nets in seining, but when present in quantity they will not be taken out, being too small for canning. Although there are many gaps in the material, the results are not without interest.

It appeared desirable to use the scale method of determining the age and the yearly amount of growth; but the material presented such great difficulties owing to the indistinctness of the winter rings that this was abandoned and the method of measurement, instituted by Petersen, alone was used.

The samples were measured on one of the usual boards, divided into centimetres, with the divisions at the half centimetres so that in each case the measurement was to the nearest centimetre. This gave centimetre groups for statistical treatment. To facilitate accurate determination of the length, the measuring board was marked on

either side of the mid-line with a series of parallel diagonal lines, making an angle of 40 degrees with the mid-line. By aligning the margins of the tail with these it was possible to spread the tail to an arbitrary, constant angle of 80 degrees.

Owing to the mixture of herring of different age groups in the samples, it was not feasible to take the average size in treating the material. The smallness of the numbers representing certain age groups in many of the samples rendered the results unsuitable for extensive statistical treatment. The only feasible method was a compromise and therefore somewhat open to objection.

The relative frequency of the various length groups in a sample indicated whether the sample consisted of more than one age group and also showed the mean size in each group. The various groups could in that way be traced through successive samples and their rates of growth determined.

The following table gives the results of the measurements:—

Locality.	Date.	Length in Centimetres.																			
		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Back Bay	I, 14				2	3	38	140	89	16	2	2	1	1									
St. Andrews	IV, 16				3	5	16	43	79	59	26	3		4	3	1							
St. Andrews	V, 13		29	29	12	11	25	49	83	45	27	3	4	5	2	1							
St. Andrews	V, 24		4	103	92	32	15	10		1													
St. Andrews	VI, 2	1	32	150	46	32	18	10	5	5	7	2	1	1		1							
St. Andrews	VI, 15			7	22	53	68	60	40	25	12	3	1		1								
St. Andrews	VI, 28			76	183	29	9	3	1														
St. Andrews	VII, 20				7	155	47	17	10	4	1	1											
St. Andrews	VII, 27		2	5		28	68	20	17	18	38	36	22	6									
St. Andrews	VIII, 12			5	9	8	71	77	14	17	29	38	29	13	1	3	2						
St. Andrews	VIII, 19			1	9	2	21	60	30	25	26	38	37	26	8	2	2	1	1				
St. Andrews	VIII, 30				1	13	2	6	11	6	8	24	40	32	15	3		2					
St. Andrews	IX, 7			1	3	10	5	3	6	3	3	12	49	53	30	15	11	1		1	5		1
Jonesport	IX, 13					1				1	19	62	52	45	42	21	20	8	6	2			
L'Etang	IX, 14								2	4	10	51	98	47	20	2							
Lepreau	IX, 14		1	15	16	8	7	6	12	14	26	69	58	25	8	3	1						
Pocologan	IX, 14							3	8	14	33	55	39	24	2	2							
Grand Harbour	IX, 15						1		2	1	2	15	51	69	49	21	17	9	4	3	1	1	
Bocabec I	IX, 16									7	1	3	16	53	37	10	2		1				
Bocabec II	IX, 16								2	23	24	36	60	98	50	13	1	1	1				
Bocabec III	IX, 16					4	11	5	6	10	9	18	59	76	45	10							
Oak Bay	IX, 28				1	9	10	7	1	1	1	11	35	83	37	7	4	2	2	2	1		
Bocabec	X, 4					3	10	5	2	1	5	38	47	63	41	17	7	6	1				
St. Andrews I	X, 14				1	6	23	25	27	23	19	44	64	68	67	47	14	9	5	7	1	1	2
St. Andrews II	X, 14					12	28	18	17	20	24	45	36	46	35	20	5	8	7	2	2	2	
St. Andrews	X, 25					1	25	32	19	8	10	23	51	60	19	12	1	2					
St. Andrews	X, 29					29	124	69	5	1	1												
St. Andrews	XI, 3						16	49	75	38	16	38	46	24	6		1						
St. Andrews	XI, 10						9	32	49	28	19	26	43	61	37	13	2	3	1				
St. Andrews	XI, 23							12	43	58	26	18	13	31	23	10	4	3				1	
Back Bay	XI, 29					2	13	67	35	47	33	49	30	10	5	6	3						
St. Andrews	XII, 6					1	9	12	32	34	21	17	8	7	6	7	8	15	8	4	1		
Bliss Harbour	XII, 21	2	13	26	38	91	88	37	24	9	2	7	1										
Mascarene	XII, 24		2	4	17	83	91	72	16	6	4		2										
Bliss Harbour	XII, 29		2	5	18	95	111	63	21	10	4	6	4	2	4								

Two of the samples may be said to be homogeneous, consisting of only one age group. They are those of June 28 and October 29. In both the actual range in size is 6 cm. (9-14 and 11-16) and the practical range is only 4 cm. (9-12 and 11-14) or perhaps 3 cm. (9-11 and 11-13). There can be no doubt that in these cases we have to do with only one age group. The curve for the sample of June 28, obtained by plotting the lengths against the numbers of individuals is given by the continuous line in fig. 1. Evidently too few length groups have been taken to give the most satisfactory curve, but we will not be far astray in taking 10 cm. as representing the mean length of the herring in the sample of June 28 and 12 cm. for those of October 29.

If we take the sample of October 4 and plot a curve to show the frequencies of the various length groups (interrupted line in fig. 1) we see very definitely a bimodal condition with two age groups represented, for one of which the length of 12 cm. may be taken as representative and for the other 19 cm. There is, however, a decided difference in the ranges of the two groups. The smaller one may be considered to have a range of 4 cm. (11-14) and the larger of 8 cm. (16-23). This might be due to the phenomenon of dispersion, the older group showing a broad low curve, and the younger group a narrow high one. I do not believe that this is the full explanation. The range is too great in the older group. It probably indicates that the older group is only apparently homogeneous, that it really consists of two age groups so similar in size as to fuse and give a good unimodal curve. Other considerations to be mentioned later support this view.

The sample of September 28 shows a similar condition. The practical ranges of the two groups would be 3 and 5 cm., respectively. The significance of this would seem to be that by the third year the spring and fall spawned schools have fused into a single group.

The third sample (III) of September 16, from Bocabec shows imperfectly a trimodal curve (fig. 1, dotted line). The sizes representative of the three groups may be taken as 12, 15 and 19 cm. The ranges are 3 cm. (11-13), 3 cm. (14-16) and 5 cm., respectively. The first and third of these groups are evidently identical with the two groups of the sample of October 4. The second group (15 cm.) was doubtless present in the latter sample but not in sufficient numbers to appear distinctly.

Let us designate these three groups A (19 cm.), B (15 cm.) and C (12 cm.). B and C give a bimodal curve with a total range of 6 cm. The growth of the smaller group (C) appears to continue farther into the fall than that of the larger group (B). This would bring them close together and make them fuse into one group with a range of 5 cm. and a mean size of 14 cm. as seems to be the case in the samples of November 3 and November 10. (for the latter see the curve in fig. 1 with alternate dot and dash). In this latter sample the larger group with a mean size of 19 cm. is evidently A and the smaller group with a mean size of 14 cm. represents (if our interpretation be correct) B and C fused. In the spring of the year group A seems to have been in the same condition as shown in the sample of April 16, with a range of 5 cm. and a mean size of 14 cm.

The degree of fusion of B and C and the relative abundance of the two groups in the various samples give a varying picture as shown in the samples of October, November, and December from St. Andrews.

In the middle of September samples from widely separated localities along the coast were examined and also a number of samples from the same locality in order to determine whether the mean size of an age group varied greatly in the different localities and in different samples from the same locality. These samples were in great part obtained through the courtesy of Captain Calder of the Seacoast Canning Co., Eastport. The localities were Jonesport (Maine), Grand Harbour (Grand Manan), Lepreau, Pocologan, L'Etang, and Bocabec. The samples showed uniformly a great preponderance of the A group. The mean size varied, being 17 cm. (Jonesport, Lepreau, and Pocologan), 18 cm. (L'Etang), and 19 cm. (Grand Harbour and Bocabec). Evidently there is an appreciable difference in the size of the same age group from different localities.

Samples were taken from several boats bringing herring from Bocabec on September 16. These showed uniformly a preponderance of the A group with in each case a mean size of 19 cm. The same is shown in a sample of September 28 from Oak Bay. This shows that herring from the inner side of Passamaquoddy bay may be considered uniform and treated together. Those from points as far away as L'Etang must be treated separately. The differences shown in the samples of September 16 from Bocabec indicate the amount of uncertainty to be associated with deductions

made from measurements of such small lots of individuals. All three show in their curves summits at 19 cm. Two show summits at 15 cm., and the third a definite step in the curve at 15 cm. Only one shows a summit at 12 cm., the other two samples having no individuals of that or neighbouring sizes. Summits (or steps) are therefore quite constant for the same age group in the same locality at any one time.

These examples will serve to show the manner in which the results of the measurements have been interpreted.

To determine the rate and period of growth of each of the different age groups, the representative length of each group, in each of the samples from Passamaquoddy bay in which it was represented in sufficient numbers, was determined in the manner described above. These lengths have been plotted against the dates on which the samples were obtained, in fig. 2. For each group a curve has been drawn connecting the circles that indicate the length of the group at different times. Where there are considerable gaps the curves have been continued with interrupted lines. There are occasional points that do not fit into the general scheme. Those of November and December, intermediate between B and C we have already interpreted as due to more or less complete fusion of B and C.

The fresh fish measure somewhat larger than the salted. For this reason the lengths in the samples of May 24 and September 16, seem high compared with the others. The samples of June 15 and November 3, show groups with mean sizes of 12·5 cm. and 13 cm. respectively. In these cases we may have group C of the preceding year which has failed to fuse with B of the same year, whereas in A these two groups are constantly fused.

In fig. 2 we have a graphic representation of the growth of the three groups A, B and C during the year. The period of growth for A and B is from May to the end of September. For C the beginning of the period is not shown, as at that time the fish were too small to be taken by the nets. It appears to continue later for this group, at least well on into October. The rate of growth for B and C is somewhat less than 2 cm. a month in the middle of the summer when the growth is most rapid. The rate for A is less, about 1·5 cm. a month as the maximum.

In many of the samples larger fish were present, but their numbers are so small as to be unsatisfactory for a determination of their mean sizes and growth. The little evidence there is, shows a group beginning at 19 cm (April 16 and May 13) and growing to 23 cm. (October 14, October 25, November 10, and December 6). Also a group reaching 26 cm. by September 7.

The determination of the ages of these groups presents difficulties. Groups B and C are quite evidently less than one year apart in age. The lack of material less than 7 cm. in length must leave the question in doubt but it is most reasonable to suppose from the rate of growth shown in 1915 that group B, beginning at a length of 8·5 cm., must have already passed through a full season's growth. The well-established fact of decrease in growth rate with increasing age would necessitate this interpretation, unless there were still greater growth during the first year. We would then reach the conclusion that group B was spawned in the spring of 1914, reached a length of 8·5 cm. by winter and in 1915 grew 6·5 cm. to a length of 15 cm. Group C would have been spawned in the fall of 1914, have reached a doubtful length by winter, perhaps 5·5 cm., and in 1915 grown perhaps 7 cm., reaching a total length of 12·5 cm.

Group A is evidently in its third summer and consists of a mixture of both spring and fall spawned fish. In the third year, therefore, the herring grow from a length of 14 cm. to a length of 19 cm. The group growing from 19 cm. to 23 cm. would consist of herring in their fourth year and those reaching 26 cm. of perhaps five year old fish.

This interpretation may be expressed in the following table:—

	First Year.	Second Year		Third Year.		Fourth Year		Fifth Year.	
	Size,	Increase	Size	Increase	Size	Increase	Size	Increase	Size
Spring spawned	8·5 cm.	6·5	15	5	19	4	23	3 (?)	28(?)
Fall "	5·5 cm. (?)	7 (?)	12·5						

I have a small quantity of very young herring collected in the tide ripplings in Passamaquoddy bay in June, 1911. Two small lots were picked up in dip nets at an interval of one week. Eleven individuals taken on June 19, range from 3·7 to 4·8 cm. in length, with an average length of 4·4 cm. Twenty-six individuals taken on June 26 range from 4·3 to 5·5 cm., with an average length of 4·9 cm. This gives a growth of 0·5 cm. for one week. This is higher than the June rate for growth, but nearly equivalent to the August rate, as shown in fig. 2. A continuance of this rate to September would give fish averaging about 9 cm. These fish must have been spawned in the spring of 1911. The fall spawners which spawn at Grand Manan and on the Nova Scotia shore do not begin until the later part of July. This confirms our interpretation of group B as fish spawned in the spring of 1914.

A comparison of these results with what has been found in Europe with entirely different methods shows a fairly close agreement. By studying the increase in the zone on the scale of the herring outside the last winter ring in a series of samples taken during the years 1910 and 1911 Lea has shown (Publ. do Circonst., No. 61, 1911) that in the herring off Norway, growth takes place during the summer from April to September. This growth period is of the same duration but a month earlier than for our coast.

As concerns the amount of growth, Lea found it to be 7 cm. in the third summer, which is much higher than what wo have found. By calculations based upon the distances between the winter rings, Hjort (Publ. de Circonst., No. 53, 1910, p. 23) found that for 246 spring-spawned fish the average growth in successive years was 8.3, 7.1, 5.9, 3.6, 2.4, and 1.7 cm. Our corresponding figures are 8.5, 6.5, 5, 4, and 3 cm. For 80 autumn spawned fish he found the following amounts 12.6, 5.1, 3.6, 2.6, 1.6, and 1.1 cm., believing that the first figure really represented two seasons' growth. Our corresponding figures are, 12.5, 5, 4, and 3 cm. The agreement is as close as could be expected, considering the imperfection of our material. We have also not been able to separate the spring spawned from the fall spawned after the second summer.

It would have been very valuable to have correlated the positions and number of the winter rings with this study of the growth from measurements. In the material examined it has been possible to make out the rings clearly only in a small number of cases. What has been seen on the whole corroborates the above mentioned interpretations as to the ages of the various groups.

CONCLUSIONS.

The data, though incomplete, indicate that: (1) there are both spring and fall-spawned young herring (sardines) in the Bay of Fundy; (2) the spring spawned schools reach a length of about 9 cm. (3.5 in.) by the first winter and of about 15 cm. (6 in.) by the second winter; (3) the fall-spawned schools reach a length of about 12·5 cm. (4 in.) by the second winter; (4) the growth during the third season is about 5 cm. (2 in.); (5) the growth during the fourth season is about 4 cm. (1·5 in.); and (6) the period of growth is from May to September.

It is most desirable that this study be continued in order to either confirm or refute these tentative conclusions and to extend the observations.

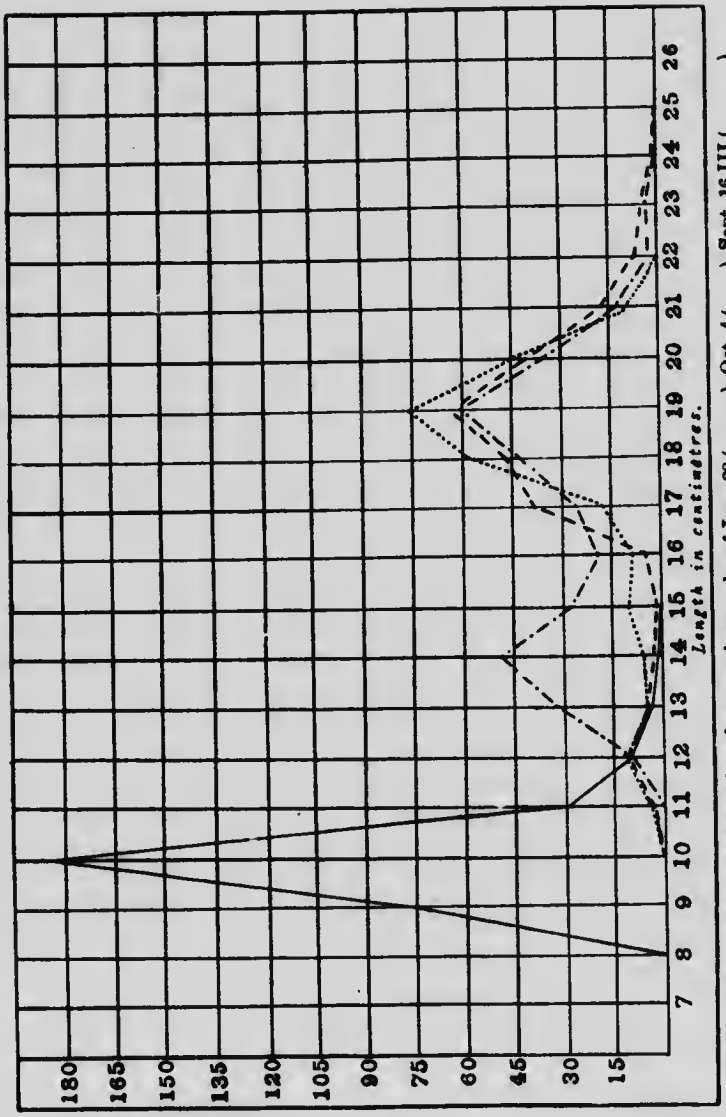

Fig. 1. Relative frequencies of length groups in samples of June 28 (———), Oct. 4 (- - -), Sept. 16 III (.....) and Nov. 10 (—. —. —.)

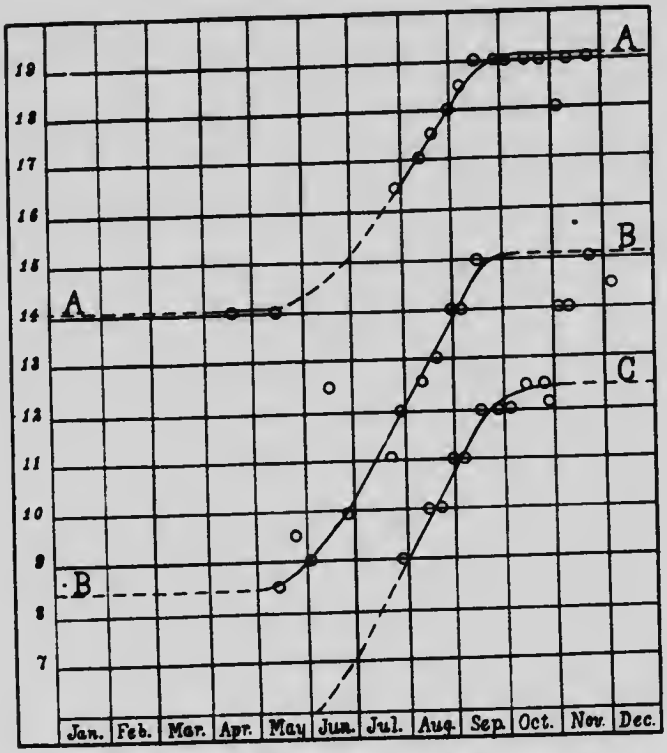

Fig. 2 Curves showing growth of Herring in 1915 The numbers indicate the length in centimetres.

Note (December 6, 1916).—A continuation of the investigations during this year has given results which agree well with those of last year. This last season differed from that of 1915 in that the "sardines" as a whole were small. This was due to the practical disappearance of the A group by the end of July, the B and C groups then in turn predominating. The A group was not as homogeneous as in 1915, consisting of varying proportions of its elements (B and C of the preceding year). It could therefore not be traced with any certainty.

The B group appeared at the end of May with an average length of about 10 cm. It was, however, mixed with larger fish until July and could be followed with difficulty. After August few were obtained. By October it had reached a length of 15 cm.

The C group was first obtained on July 8, with a length of 7 cm. By September it had become the dominant group and has remained so. During September, October and November it has continued to grow in length, increasing from 10·5 cm. (September 6) to 13 cm. (November 24). The growth was not, however, as rapid as during July and August.